REMARKS

Applicants acknowledge the Office Action of 5 MAY 2006 and request reconsideration of the claims, as amended.

Responsive to Paragraph 3 of the Action, claim 1 no longer includes all the features of claim 3, so it is not necessary to cancel claim 3, nor to change the dependencies of claims 4 and 7.

Applicants appreciate the Examiner's fax of APR. 27, 2006 indicating that addition of the phrase "with an ignition advance angle" would place certain claims in condition for allowance. Although Applicants have used this phrase *for purposes of explanation*, Applicants prefer other claim terminology, for accuracy and in order to maximize definiteness of the claims. For example, specification page 15, lines 15-17, state: "ignition angle shift must be performed only above a predefined minimum rotation speed." Page 18, lines 22-25, make a similar statement. Accordingly, the foregoing amendments to the claims were prepared with this definiteness objective in mind.

SUPPORT FOR CLAIMS AS AMENDED

Main apparatus claim 1 has been rewritten to recite 4 paragraphs (a)-(d) which define operations which are performed in a motor operating according to the invention. Subparagraph (a) is supported at specification page 6, lines 6-18. Subparagraph (b) is supported at specification page 8, lines 8-38, and page 28, lines 13ff. Subparagraph (c) is supported at specification page 31, lines 5-25, and illustrated by FIG. 21A. Subparagraph (d) is supported at specification page 19, lines 7-21, and illustrated by FIG. 9.
If the Office needs further guidance, kindly contact Applicants' counsel by telephone or email.

Specification pages 10-11 are directed to a preferred embodiment

of the invention, in which one uses a microcontroller having only a single timer. Such a microcontroller is less expensive than a microcontroller having two or more timers.

FIG. 7 is a graph showing how a single timer can do "double duty" by performing two functions (thereby avoiding the cost of a 2nd timer):

a) It measures the time T_I for the "early ignition." Once this time interval has expired, it triggers the Timer Interrupt shown in FIG. 10 (see page 16, 2nd paragraph), resulting at S320 or S322 in performance of a commutation (see page 17, first par.).

b) Immediately thereafter, the timer is loaded with a new value and counts again, so that one obtains the time t_E, from which one calculates (according to formulas in S254 & S258, FIG. 9) the time t_H which is inversely proportional to motor speed.

Thus, two "duties" are performed almost simultaneously, namely the measurement of t_B and T_H and the starting of the interrupt for the commutation, enabling one to operate with only a single timer. Achieving such functionality with a "low hardware investment" indicates *real ingenuity*! A less-skilled programmer would need two timers in the hardware, a 1st timer to measure the times t_B and t_E, and a 2nd timer to measure the time t_I.

SKETCH 1 illustrates this.

One sees that, at A, the commutation is controlled and that simultaneously, at A' the values t_B and t_E are measured.

Similarly, at B, the commutation is performed, while at B' the times t_B and t_E are measured.

Likewise, at C, the commutation is performed, while at C' the values t_B and t_E are measured.

Precise commutation without jitter is only possible when the measurement of t_B and t_H is not far removed in time from the commutation. SKETCH 2 shows that the measurement of t_B and t_E should happen in the same angular range as the commutation happening one or more rotations later. This gives the best results.

BACKGROUND:

The present invention is directed to so-called "early ignition" in an electronically commutated motor. By means of the early ignition, it is intended to increase the power of the motor at high RPM, because the current can rise faster after commutation, when the commutation is shifted a bit earlier in time. This is analogous to what happens in an auto engine, when at high RPM the ignition is automatically shifted to an earlier point in time, to increase the power. Therefore, by analogy, one employs the term "early ignition" in the electric motor field, although nothing is "ignited" in an electric motor.

FIG. 22 of the present application is a graph of the current trace, over time, in a motor without early ignition. This current rises, after the commutation, only gradually, because the high induced voltage in this region hinders a quick rise.

FIG. 23, by contrast, shows the course of events when "ignition" is advanced by a time interval t_ZW before the point HN. In this case, at the start the induced voltage is low or even negative, and therefore the current rises very quickly, so that, at high RPM, a significantly higher motor power results. At low RPM, one does not need the "early ignition" because the induced voltage is low; the latter is proportional to RPM. In the present invention, early ignition is used when it is useful, generally from 1500 RPM or 2000 RPM upwards, by switching the current ON a time interval t_ZW early.

Comparison of FIGS. 22 & 23 of this application shows that this is a very sensitive procedure; i.e. if one commutates according to FIG. 22, one gets an **unfavorable shape** of the motor current and low power output with low RPM, while if one commutates according to FIG. 23, a small time interval t_ZW early, perhaps 200 microseconds (see specification page 19), the current i_M rises very quickly and one obtains high power output and high RPM.

This means that the commutation instant HN of FIG. 23 must be chosen *very precisely*, since otherwise the motor operates very irregularly.

The attached Sketch 1 illustrates the principle of the control process used. At I/1, the times t_B and t_E for the beginning and end edges of the Hall signal are measured. These instants generally have a spacing of 180 degrees (electrical) from each other.

At I/2, from those values, the time t_H is calculated, as shown in FIG. 9, steps S254 and S256. Thereafter, in step S268, the value t_TI is calculated; this is designated in sketch 1 with R. This time value is derived directly from the preceding measurements of t_B and t_E and enables an extremely precise commutation, which is necessary for the reasons previously explained.

Using this time value t_Ti, designated in sketch 1 with R, the commutation is thereafter very precisely controlled, in stage I/3.

This is repeated for each successive commutation:

At II/2, t_B and t_E are measured.

At II/3, a new value t'_H and a new value R'= t_TI' are calculated.

At II/4, these values are used in the commutation.

Similarly, at III/3, the values t_B and t_E are measured.
At III/4, a new value t'''_ H is calculated, from it a new value R''= t_TI'' is calculated and is used in commutation at III/5.

In this manner, even with extremely short time spans t_ZW of, for example, 200 microseconds, a stable and low-noise operation of the motor is enabled. In other words, the value for t_H must be both "fresh" and very exact. The application discloses several embodiments, all of which serve the goal of enabling the motor to run quietly and with high power output.

A preferred variation is that recited in claim 38, which is illustrated in FIG. 18, and is used by the assignee in many motor models. Applicants enclose explanatory Sketch 2.

This is shown for a 4-pole rotor like that of FIG. 18.

Such a rotor can never be perfectly magnetized, as FIG. 18 illustrates, and thereby errors will automatically result.

Using the method shown in Sketch 1, these errors are reduced, since these values are measured within an angular range from 0° to 180° (elec.) and these values are subsequently used within the angular range 360° to 540° for commutation. The ranges 0° to 180° and 360° to 540° are similar in a 4-pole motor, but unfortunately not identical. Therefore, it is even better to, for example, measure within the range 0° to 180° and subsequently, after a <u>full</u> revolution of the rotor, to use the measured values in the same range 0° to 180° for commutation, since these two regions are fully identical, and the errors in magnetization are fully compensated. One thereby obtains very smooth motor operation, and the small fluctuations in timing of the commutation instant, the so-called "jitter," are on the order of millionths of a second.

The reason for the "jitter" is that the interrupt, which controls the commutation, does not occur **immediately** upon receipt of the command therefor, but rather only after 1 or 2 or 3 cycles of the microprocessor, typically after 2, 4 or 6 microseconds. In other

words, the instant of the commutation can fluctuate by these small intervals.

These minimal fluctuations typically cause no trouble. However, larger fluctuations would lead to a "chirp" of the motor, which would impair its efficiency and shorten its operating life.

The reason for this is that, in such motors, one must always use a so-called "DC link capacitor" which one must imagine in FIG. 1, connected between terminal UN (top right) and ground.

When the instant of the commutation constantly fluctuates, a so-called "ripple current" will flow into and out of the capacitor. For example, when a 4-pole rotor rotates (mechanically) 100 times per second, that means 200 electrical rotations and, since for each electrical rotation, 2 commutations occur, one observes a current with a frequency of 400 Hz to this capacitor. The amplitude of this current rises, the more strongly the instant of commutation fluctuates, and, when strong fluctuations occurs, this current heats the capacitor up so much that it fails, causing the motor as a whole to fail. In other words, when the capacitor goes bad, one has to **throw away** the motor.

ART REJECTION--SECTION 102

GEE & THORN/EMERSON ELECTRIC (USP 4,743,815), cited as allegedly anticipating independent claims 1, 30 and 43, and their dependent claims, uses a different motor control scheme. GEE discloses a three-phase motor with a control scheme based upon the Zero-Crossing points (ZRC) of the induced voltage (see col. 4, line 15). The DC power supply voltage (col. 4, line 28) increases with increasing rotation speed. The motor uses phase-chopping control, i.e. the turn-on instant is <u>after</u> the associated zero crossing point (see col. 8, line 12). Thus, the GEE motor belongs in the "late ignition" genre, not the "ignition advance" genre of the present invention. Upon each zero passage of the induced voltage, an interrupt is generated by the monoflop 37 of FIG. 4 (see col. 6, lines 28-29) or alternatively, by gate G15 of FIG. 6.

FIG. 2 shows the induced voltages ("back-EMFs") VAN, VBN and VCN in phases A, B, and C, with reference to neutral point N.

The bottom trace in FIG. 2 shows the zero passages ZR and the points NG where the induced voltage reaches its negative maximum. The commutation happens in this sector between ZR and NG, as described at col. 4, lines 18-33. The "ignition angle" measured after ZR, is designated THETA (see col. 7, lines 66ff).

In a motor with phase-angle control as shown by GEE, the precision of the commutation timing does not matter greatly, since a few electrical degrees one way or another are not critical in a low-power motor operating on relatively high voltage, e.g. 280 V (col. 5, line 39) rectified from the AC power grid (col. 4, line 31). GEE does not teach or suggest the operating steps recited in claim 1, subparagraphs (a)-(d).

OPERATIONAL STEPS ACCORDING TO GEE DISCLOSURE:

Calculate the frequency (corresponding to motor RPM) 120 times/sec. (See col. 7, lines 51-52, and FIG. 7A, top oval).

Calculate therefrom VLIMIT (FIG. 7A) (Col. 7, lines 57-60)

Calculate TVC for rectifier 15. (Col. 8, lines 9-17)

Use that to set the voltage of the DC link circuit at, e.g. 280V.

Retrieve a value TS (corresponding to the 280V) from a table for specifying a target speed for the motor. (Col. 8, l. 44ff)

Load value TS into counter B. (Col. 9, line 56)

Specify the time TEMF (between back-EMF & commutation event).

Decrement counter B (representing time between commutations).

Commutate at the STEP shown in FIG. 7C.

It is readily apparent that the GEE steps fail to correspond to the operation steps recited in subparagraphs (a)-(d) of claim 1.

Further, contrary to the Office's contention in par. 15 of the Office Action, the GEE steps described at col. 8, lines 49-61 **do not correspond** to the steps recited in claim 30, subparagraphs (e)-(f).

Method claim 38 depends from independent method claim 30, and sets forth *additional* steps. It has been revised for greater clarity.

Claim 38 is directed to a highly sophisticated motor product, in which everything is timed precisely, down to millionths of a second, in order to **maximize** power output. By contrast, GEE is directed to phase angle control for a 3-phase motor, i.e. a method for **reducing** motor output power. Since the GEE motor can operate at differing speeds, the voltage in its DC link circuit is varied as a function of RPM. For this purpose, in FIG. 7A, (col. 7, lines 51-52), the frequency FRQ is calculated, and an operating voltage VLIMIT is calculated. In closed-loop operation, a value TVC for the rectifier

15 (FIG. 3, top left) is calculated, so that the voltage in the DC link circuit can be set to this value, e.g. to 280 volts, as recited at col. 5, line 39. Col. 8, lines 11-14, say that "variable TVC is the time after the zero crossing of the a.c. power line for the SCR firing." SCR = Silicon-Controlled Rectifier.

The control of voltage in the DC link is described at col. 8, lines 37-43.

Thereafter, a Time/Step TS "is set equal to a function of VQ and VQ1 from a look-up table to obtain the frequency from the voltage." (Col. 8, lines 44-46).

The same applies for open-loop operation, i.e. here also, the value TS is taken from a look-up table; see col. 8, lines 57-61.

This value TS is then used in the FIG. 7C routine to control the commutation. It seems to be a kind of target value for speed control.

According to col. 9, lines 53-62, in the commutation process, the interval between commutations is set by timer B, i.e. starting at one commutation, timer B is decremented until it reaches 0, and then a Timer B interrupt triggers the next commutation.

GEE thus fails to disclose or suggest that, prior to each commutation, one should measure a value proportional to RPM, and then **use the measured value** to **exactly** control the commutation timing. Rather, GEE teaches to control commutation by the value TS, taken from a table and calculated as a function of VQ and VQ1; see col. 8, lines 44-48.

The content of GEE thus directs those in the art in a totally different direction, which is incompatible with an "advance angle" approach. Using the GEE approach, extreme fluctuations of motor current and RPM would result. The motor could not be sold competitively today because it would operate very loudly and would

have a short service life before its capacitor burned out. After lengthy study, counsel believes the GEE disclosure to be **non-enabling**, and probably inaccurate in important respects.

Still further, contrary to the Office's contention in par. 23 of the Office Action, the GEE steps described at col. 7-8 do not correspond to the operating elements recited in claim 43.

CLAIM REJECTION-SECTION 103

Dependent method claims 39-42 (depending directly or indirectly from independent method claim 30) were rejected as unpatentable over GEE in view of "Official Notice." Since GEE fails to teach or suggest the subject-matter of **parent** claim 30, no amount of "Official Notice" can supply the unsuggested steps of claim 30, much less the **additional** refinements of the method recited in **dependent** claims 39-42.

With respect to claim 39, the Office has not pointed to any mention in GEE of "non-time-critical process steps," much less to a teaching of **when** to execute such steps.

Claim 40 further specifies calculation of a "rotation-speed-dependent value" which is not mentioned in GEE col. 7, lines 43-63. Rather, GEE at col. 8, lines 2-48, recites a complex formula for calculating a value THETA which includes THC, a "commanded phase angle **from a potentiometer**" so it is not apparent whether GEE's control value is *proportional to anything* in particular. Further obscuring matters, lines 4 and 28 seem to be the <u>only</u> references to the potentiometer in the **entire** GEE specification & drawings.

Claim 41 recites loading a startup value from a non-volatile memory, of which no mention in GEE has been cited.

Claim 42 recites modifying the contents of the non-volatile memory of claim 41, via a bus connection. No bus connection and no content-modification step in GEE have been cited.

The Office is requested to reconsider the section 103 rejection, in the light of the amendments made, and in the light of the Ex parte Scott & Lin decision of the Board of Appeals concerning "Official Notice" taken in S.N. 09/392,276, now USP 6,727,578, issued 27 APR. 2004. In that case, the Board found that the Examiner's "Official Notice" rejection was based on impermissible hindsight reasoning. Reconsideration of the section 103 rejection is solicited.

DOCUMENTS CITED BUT NOT RELIED UPON

Paragraph 38 suggested that US patents to SKINNER, ERDMAN, ROSSI, BEIFUS and FUKAO were "pertinent."

SKINNER+/EMERSON ELECTRIC (USP 6,768,279) discloses a motor with a digital controller 10 including a microprocessor 14, a ROM 16 and an EEPROM 18. The latter can be programmed from a programming device 22 via an optical coupler 30 and, according to FIG. 3, contains the motor operating characteristics 42 of any of various motor models (see col. 1, lines 17, 22, 60-65). As described at col. 5, lines 20-32, setting the three rotary switches SW1, SW2 and SW3 of FIG. 2 permits selection of a particular application. Altogether, 512 selections are possible. The motor M is controlled using a three-phase full bridge circuit 12. The relevance of this circuit to the present invention is not readily apparent.

ERDMAN+/GENERAL ELECTRIC (USP 6,414,408, issued 2002) discloses a motor of the general type, in which the present invention could be used. It is a two-phase, two-pulse motor intended **for use in a refrigerator**, in order to save energy by increased efficiency; see col. 1, line 55ff. The disclosure makes sweeping statements without disclosing much detail. The electronic parts are on a circuit board 336, shown in FIG. 5. The parts include a Hall sensor 439, a varistor 3611 (FIG. 19), an ASIC 200 (FIG. 22) and a large electrolytic

capacitor 361, forming part of the DC link circuit, and constituting the largest part shown in FIG. 5. The rotor has three circumferential magnets 316, 317, 318, shown in FIG. 6 and described at col. 9, line 31. The three-pole design is said (col. 13, lines 51ff) to provide more reliable starting performance.

The ERDMAN motor (design circa 1992) is considerably larger than a typical contemporary motor of the same power would be. The ERDMAN motor, although relatively weak, requires, for its DC link circuit, a very large electrolytic capacitor 361, shown in FIG. 5 and mentioned at col. 8, lines 51-52. In FIG. 21, the capacitor is designated 142 and labeled to indicate that, in a 200-volt system, it has a size of 22 microfarads; see col. 16, lines 17-19.

This **large** capacitor is needed only because the motor is poorly designed and has a fluctuating commutation time. If the commutation timing were very consistent, as in the present invention, a **smaller** capacitor would suffice, and the motor would have a much longer service life, since then the service life would be limited only by the mechanical parts of the motor, rather than by the mean-time before capacitor burn-out.

According to GEE, the motor speed is measured only 120 times per second, while in the present invention, the motor speed is measured before every commutation. At high motor speeds, this is much oftener than 120 times per second. The system as recited in claim 1, as amended, makes the commutation timing very precise, so that it deviates from an "ideal" timing only by microseconds. Since the ERDMAN design has no commutation time adjustment, it has little relevance to the presently claimed invention.

ROSSI/ST Microelectronics (USP 6,107,763) is directed to current generation for a multi-phase sinusoidal motor, as shown in FIG. 2,

top. The motor can operate either using Hall sensors, or in "sensorless" mode by detecting rotor position from back-EMF.

In this circuit, the values of the sinusoidal signal are stored in a Read-Only Memory (ROM) as shown at bottom right in FIG. 2, but also required in the FIG. 1 embodiment. FIG. 2 illustrates a pointer S which designates the value, in the table, which is to be currently retrieved. FIG. 2 also shows a register T which can be used to store a value for "phase anticipation" as mentioned at col. 4, lines 39-42.

The ROSSI system has "real" Zero-Crossing signals ZCR generated by zero crossings of the induced voltage (col. 3, lines 16-20) and "synthetic" ZCR pulses ("forced synchronizing pulses") generated by the circuit MSF FALSE shown in FIG. 2, lower left, as mentioned at col. 4, lines 66ff.

The circuit of FIG. 2 serves to produce a simple switchover from "open loop mode" to "closed loop mode" and back, as described at col. 4, lines 29-67. Applicants respectfully submit that this fails to suggest the present invention, as recited in claim 1, as amended.

BEIFUS/G.E. (USP 6,104,113) discloses a single-phase permanent magnet motor with an internal rotor 16 and a coil assembly 62 for sensing rotor position. Commutation is said (col. 5, lines 44-50) to be "coincident with, or in advance of, the estimated back EMF zero crossings" of the induced voltage. Exactly how this is accomplished is not disclosed. Applicants respectfully submit that BEIFUS fails to teach or suggest the present invention, as recited in claim 1, as amended.

FUKAO/EBARA+SEIKO (USP 5,936,370) discloses a motor or generator with a magnetic bearing. It has a controller for the position of the shaft, as shown in FIGS. 3(a), 7 and 8, and described in columns 7-8 with reference to FIG. 8. Wear is minimized by "levitating" the rotor 40, as described at col. 3, line 3. Col. 2, lines 42-56, describe alternative rotor and winding embodiments.

In order to minimize the number of sensors, the motor operates in "sensorless mode." Two embodiments are disclosed, that of FIG. 1, in which the controller B1 receives multiple signals, e.g. target frequency for motor speed, a sinusoidal signal, and a feedback signal, and the simplified version of FIG. 5.

This disclosure appears to have very little relevance to the presently claimed invention.

CONCLUSION

In view of the foregoing amendments and explanations, Applicants respectfully submit that independent claims 1, 30, 43, 46 and 47, and their respective dependent claims, are now clear, and patentably distinguish over GEE, SKINNER, ERDMAN, ROSSI, BEIFUS, FUKAO, and the other art of record, taken singly or in combination.

If the Examiner detects any remaining informalities which need to be corrected to place the application in condition for allowance, a telephone call to Applicants' counsel is invited.

09/ 806,619

No extension of time or extension fee is believed necessary in connection with this submission; if any fee is necessary, please construe this paper as a Petition therefor, and charge the fee to Deposit Account 23-0442.

Respectfully submitted,

Milton Oliver

Milton Oliver, Reg. No. 28,333
WARE, FRESSOLA, VAN DER SLUYS
& ADOLPHSON, LLP
PO BOX 224
MONROE, CT 06468
TEL (203) 261-1234
FAX (203) 261-5676

Enclosures:
- SKETCH 1 with 2-page explanation
- SKETCH 2

P61.12D217
Explanation of sketch

Rotor position is measured by a signal "Hall" that is generated by Hall sensor 40 shown in Fig. 1, upper right. In the case of a four pole permanent magnet rotor 39 shown in Fig. 1, the Hall signal "Hall" has the shape shown in the sketch, i.e. i~~s~~t is high for 180° el., low for the next 180° el., high again for 180° el., and low again for 180° el., and then one revolution is over and things repeat.

The signal Hall has flanks where it goes from low to high, and from high to low. These are measured by Hall interrupts shown in Fig. 8, and one thus obtains the times t_B and t_E of these flanks.

In the sketch, this is shown at I/① and takes 180° el.
Next, one calculates the time difference
t_H = t_B-t_E
as shown at S256 in Fig. 10. t_H is short when the motor runs fast, and it is long when the mother runs slowly. Based on t_H, one calculates a value
R = t_H - t_ZW
This is done at I/② and also takes 180° el.

t_ZW is a fixed time of a few microseconds determining "early ignition", i.e. commutation of the motor is shifted toward early. This is shown in Fig. 25 and causes a great improvement in the shape of the motor currents i_M which is demonstrated by comparing Fig. 24 (without early ignition) with Fig. 25.

During the next 180° el., the time R is measured, and at the end of R, commutation takes place. This happens in I/3.

Clearly, one needs a newly calculated value R' for time frame 4, so one dues the same calculations in II/②, II/3 and II/4.

And one needs a newly calculated value R'' for time frame ⑤, so one does the same calculations in III/3, III/4 and III/⑤.

The problem then is, that e.g. in time frame (3), one has to do simultaneously

a) in I/(3) the measuring of R plus the steps needed for commutation
b) in II/(3) the calculation of t'_H and of R', and
c) in III/(3) the measuring of t_B and t_E.

Since one only has a cheap microcontroller, this interleaving of several jobs in the same time frame (the interleaving goes on all the time while the motor is running) takes some ingenuity and, at the time of the application, clearly was outside the reach of the man of the art.